

ON THE

Determination of Vapour Pressures of
Organic Alcohols and Acids,

AND THE

Relations existing between the Vapour Pressures of
Organic Alcohols and Acids.

INAUGURAL DISSERTATION FOR THE DEGREE
OF DOCTOR OF PHILOSOPHY,

Before the Philosophical Faculty of the University of Freiburg.

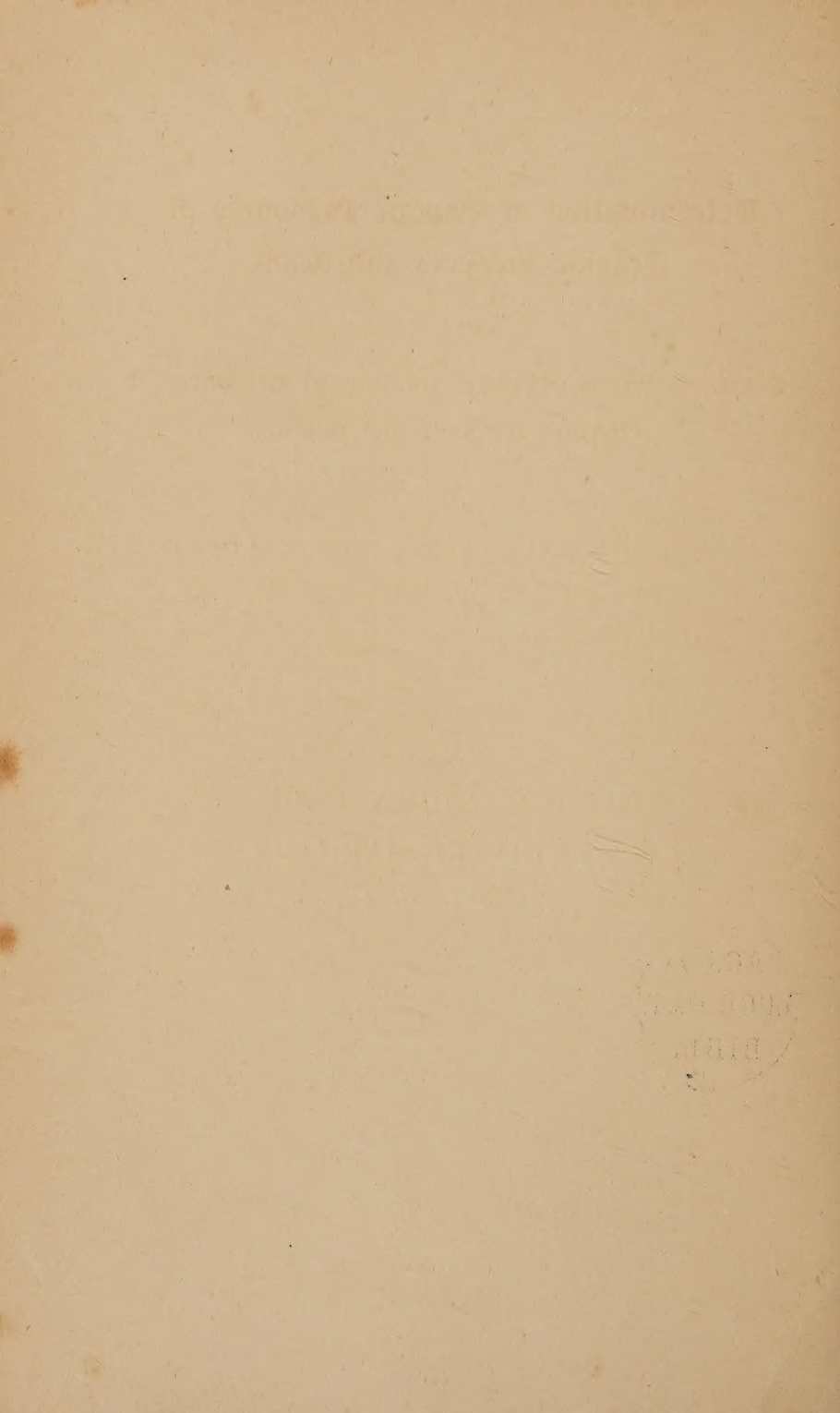
BY

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ON THE
DETERMINATION OF VAPOUR PRESSURES OF
ORGANIC ALCOHOLS AND ACIDS, &c.

THIS work was carried out by me under the direction of Professor Ramsay, at University College, Bristol, with a view to obtaining the Vapour Pressures of a considerable number of Organic Alcohols and Acids, making the series as complete as possible, by a very wide range of observations; and subsequently to observe the relation existing between the vapour pressures of the acids and alcohols so obtained.

Apparatus used.—The form of apparatus I used was one described by Ramsay and Young (*Journal of Chem. Soc.*, Jan., 1885), which consists of a glass tube about 20 mm. in diameter and 2 dc.m. in length. One end of this tube is closed before the blowpipe, whilst the other extremity is fitted with an indiarubber stopper, perforated by two holes; through one hole passes a thermometer, the bulb of which reaches nearly to the bottom of the tube, and is tightly bound with cotton wool; through the other hole passes a small tube, one end of which is drawn out to a fine point, and touches the thermometer stem inside the apparatus, whilst the other extremity is connected by means of an indiarubber tube (which can be closed by a screw-clip) to a bulb con-

taining the liquid to be examined ; by opening the screw-clip a stream of liquid can be caused to flow down the stem of the thermometer and saturate the cotton wool surrounding the thermometer bulb.

A tube about 15 mm. diameter is sealed into the wide tube at about 30 mm. from the stoppered end. This tube terminates in a glass bulb of 150 c.cs. capacity, which is so arranged that it can be immersed in a freezing mixture. From the bulb passes a T-tube, closed at one end by a screw-clip and indiarubber tube, whilst the other limb is connected with an air-pump and mercury gauge ; the height of the mercury in the latter is read off on a mirror scale graduated in millimetres. As the atmospheric pressure was also required to be known, it was found convenient to read the height of the mercury in the barometer on the same scale as that employed to read the height of the mercury in the gauge. Errors arising from capillarity were avoided by using two tubes of the same internal diameter for the gauge and barometer.

In order to use the apparatus, it was first exhausted of air as completely as possible. The tube carrying the thermometer being held in a vertical position, the lower end of the tube was immersed in a bath of some liquid which was heated to a temperature at least 30° C. above the boiling point of the substance under examination. The bulb or condenser having been placed in a freezing mixture, a little of the liquid whose vapour pressure was required was next allowed to run down the stem of the thermometer, and the cotton wool round the bulb of the thermometer became saturated with the liquid, evaporation then took place from the cotton wool, the vapour being caught and collected in the cooled bulb. The

temperature of the thermometer when constant was observed, together with the height of the mercury in the gauge and barometer; a little air was next admitted by opening the screw-clip on the T-tube, thus increasing the vapour pressure. The thermometer and mercury in the gauge and barometer were again read, this process was continued till a sufficient number of observations had been made. When the cotton wool became dry, fresh liquid was admitted down the thermometer stem.

This method has many advantages over the "barometer-tube" method, inasmuch as the temperature of the whole apparatus has not to be kept constant, also a very large number of observations can be made in a short time; moreover, the necessity of admitting the substance free from air is avoided; again, the barometer and gauge are side by side, at the same temperature, and removed from the source of heat. The only correction necessary is one in which the temperature of the air in the pump is reduced to 0°C .

The following are the alcohols and acids which were used:—

Methyl Alcohol (obtained from Kahlbaum free from acetone) was freed from water by distillation, after standing over calcium oxide for 24 hours; the last traces of water were removed by treatment with small quantities of metallic sodium, and subsequent distillation. B.P. 65°C .

Ethyl Alcohol: a nearly pure specimen was provided by Dr. Ramsay; this was distilled after treatment with small quantities of metallic sodium. B.P. 78°C .

Nor. Propyl Alcohol (pure ? from Kahlbaum) was distilled after treatment with metallic sodium; the greater part boiled constantly at 96.6°C . This fraction was used.

Iso-Butyl Alcohol (supplied pure from Kahlbaum) was fractionated after treatment with metallic sodium; the greater part passed over at 108°C . This was taken as pure.

Iso-Amyl Alcohol: a specimen provided by Dr. Ramsay was fractionated as in the previous cases; after treatment with metallic sodium, that portion which boiled constantly at 130.18°C . was used.

Glycerine: a specimen was distilled *in vacuo*, and the distillate collected when the boiling point was constant; this portion I concluded was free from water.

Formic Acid (obtained from Kahlbaum) was distilled, and the fraction which boiled constantly at 100.75°C . was used.

Acetic Acid: a pure specimen was given me by Professor Ramsay. B.P. 118°C .

Propionic Acid (obtained from Kahlbaum): this was fractionated; the greater part boiling constantly at 140°C . was used.

Iso-Butyric Acid was distilled, and the portion boiling constantly at 153.3°C . was taken as pure.

Iso-Valerianic Acid: an impure specimen was distilled, and the fraction boiling above 150°C . was repeatedly shaken with fresh quantities of phosphoric anhydride. On again distilling, the greater portion passed over at 174.9°C . This fraction was used.

EXPERIMENTAL RESULTS.

The numbers representing the vapour pressures of these alcohols and acids at different temperatures are given on Tables Nos. I. to VI.

In all cases two series of experiments were made for each substance, with a view to checking the results obtained.

The temperatures given on Tables I. to VI., which correspond to definite vapour pressures, also represent the true boiling points of the substances used at those pressures; for in all cases the temperature of the bath (used for heating the tube containing the thermometer) is at least 30° C. above the boiling point of the substance under examination. Errors arising from the vapour becoming superheated are entirely avoided; for even though the vapour may be superheated, yet the liquid in contact with the thermometer bulb must be at the true boiling point, since it has a free surface of evaporation.

The numbers given also represent the vapour pressures of the substance at any given temperature, as may be seen by comparing the numbers, where possible, with those obtained by Regnault; his results being obtained by the "barometer-tube" method.

In the following Table the vapour pressures of methyl and ethyl alcohol are given; Regnault's results, observed by the "barometer-tube" method, being compared with the results I obtained by the method above described for pressures between 50 mm. and 550 mm. The numbers obtained by the two observes will be seen to agree sufficiently closely to verify the accuracy of the method used

by me, on the supposition that Regnault's numbers are trustworthy.

Table shewing Vapour Pressures of Methyl and Ethyl Alcohol, as observed by Regnault and by Richardson.

Mm.	METHYL ALCOHOL.		ETHYL ALCOHOL.	
	Regnault.	Richardson.	Regnault.	Richardson.
50	10 ° C.	9 ° C.	22·2° C.	21·8° C.
100	22·45	21·8	34·8	34·0
150	30·2	30·0	42·2	41·8
200	36·0	35·9	48·0	47·4
250	40·9	40·5	52·6	52·2
300	44·7	44·4	56·6	56·0
350	48·0	47·9	60·0	59·5
400	51·1	51·0	62·7	62·5
450	54·0	54·0	65·9	65·5
500	56·8	56·5	68·5	68·3
550	58·8	58·5	70·3	70·0

Observed Relations between Vapour Pressures of the Alcohols and Acids.

It has been observed by Drs. Ramsay and Young (*Phil. Mag.*, Dec., 1885) that a relation exists between the *ratios* of the *absolute temperature* of the two groups, Bromo- and Chloro-Benzine, and Chloride and Bromide of Ethyl.

It has been found that the ratio of the absolute temperature of these bodies at any given vapour pressure is a constant. Thus the ratio of the absolute temperature of Bromo-benzine to Chloro-benzine when the vapour pressure of both is 100 mm., is $\frac{364.3}{343.5}$, or 1:1.061; and at the other vapour pressures, up to 700 mm., the ratio remains absolutely constant at 1:1.059.

Again, the ratio of the absolute temperature of Ethyl Bromide to Ethyl Chloride has been determined for pressures between 150–5000 mm., and the ratios vary only between 1.089–1.091. It follows from this that, in the case of some closely allied groups, the ratio of the absolute temperature at any vapour pressure is a constant.

My next object was to observe the relation existing between the ratios of the absolute temperatures of the different members of the Alcohol and Acid series. I first converted the degrees centigrade (corresponding to the vapour pressures) into the equivalent absolute temperatures, and from these obtained the *ratios* of the absolute temperatures of the different alcohols amongst themselves, and the acids amongst themselves, for vapour pressures between 50 mm. and 750 mm. The results are given on Table VII.

It will be seen that in the case of Methyl and Ethyl

alcohol, that the ratio of their absolute temperatures at 50 mm. is 1:1.045, but that the ratio diminishes with increased vapour pressure to 1:1.035 at 700 mm.

A similar decrease in the ratio between Ethyl and Propyl alcohol is observed from 1:1.062 to 1:1.051.

Comparing Propyl and Butyl alcohol, a much smaller variation in the ratio of the absolute temperature is observed, viz., at 50 mm., 1:1.027, rising to 1:1.029 at 750 mm. (in this case the ratio tends to increase slightly with rise of vapour tension); whilst in the case of Butyl and Amyl alcohol, the ratio is practically a constant throughout.

Comparing the acids among themselves, it will be observed that the ratio between the absolute temperature of Formic and Acetic acids varies considerably, being at low vapour pressures 1:1.059, gradually falling, as the vapour pressure rises, to 1:1.047. Again, between Acetic and Propionic acids, a fall in ratio, as the pressure rises, is observed (viz., from 1:1.071 to 1:1.054).

Ascending the series, we see that Propionic and Butyric acids are much more nearly constant in the value of their ratios at different pressures; viz., 1:1.030 to 1:1.037, this value becoming very nearly constant in the case of Butyric and Valerianic acids.

From these numbers it would appear—

1. That the ratio of the absolute temperature of the *lower alcohols and acids diminishes* as the vapour pressure rises.
2. That among the *higher alcohols and acids* in the series the value of the ratio tends to become a constant number for all vapour pressures.

Although it is only in the case of nearly allied substances—such as bromo- and chloro-benzine, and ethyl chloride and bromide, and some of the higher alcohols and acids—that the ratio of the absolute temperature is a constant for any vapour pressure, yet a relation is found to exist between the ratios of the absolute temperatures of a very large number of substances—in fact, as far as experiments have gone, applicable to all bodies.

It has already been pointed out that the numerical value of the ratio of the absolute temperature of any two bodies may be a constant value for all vapour pressures, or it may diminish with increased vapour pressure.

Now, if we call R ratio of the absolute temperature of two bodies, A and B , at any given vapour pressure, the same for both,—and let t = the absolute temperature of one of the bodies, say A , corresponding to that vapour pressure; let R' = ratio of the absolute temperature of A and B at the other vapour pressure at which the temperature of $A = t'$, and let r = increase or decrease in the numerical value of this ratio per unit rise of temperature of A ; then $R' = R + r(t' - t)$; in other words, r = a constant value per unit rise in temperature—that is to say, the ratio of the absolute temperature of any two bodies corresponding to an equal vapour pressure is either constant at all vapour pressures (when $r = 0$), or else the ratio increases or decreases with rise in temperature by an amount which is *directly proportional* to the *rise in temperature*.

When r is greater or less than 0, its value may readily be determined graphically by representing the absolute temperatures of one of the two bodies (corresponding to

known vapour pressure) as ordinates, and the *ratios* of the absolute temperature of that body as *abscissæ*.

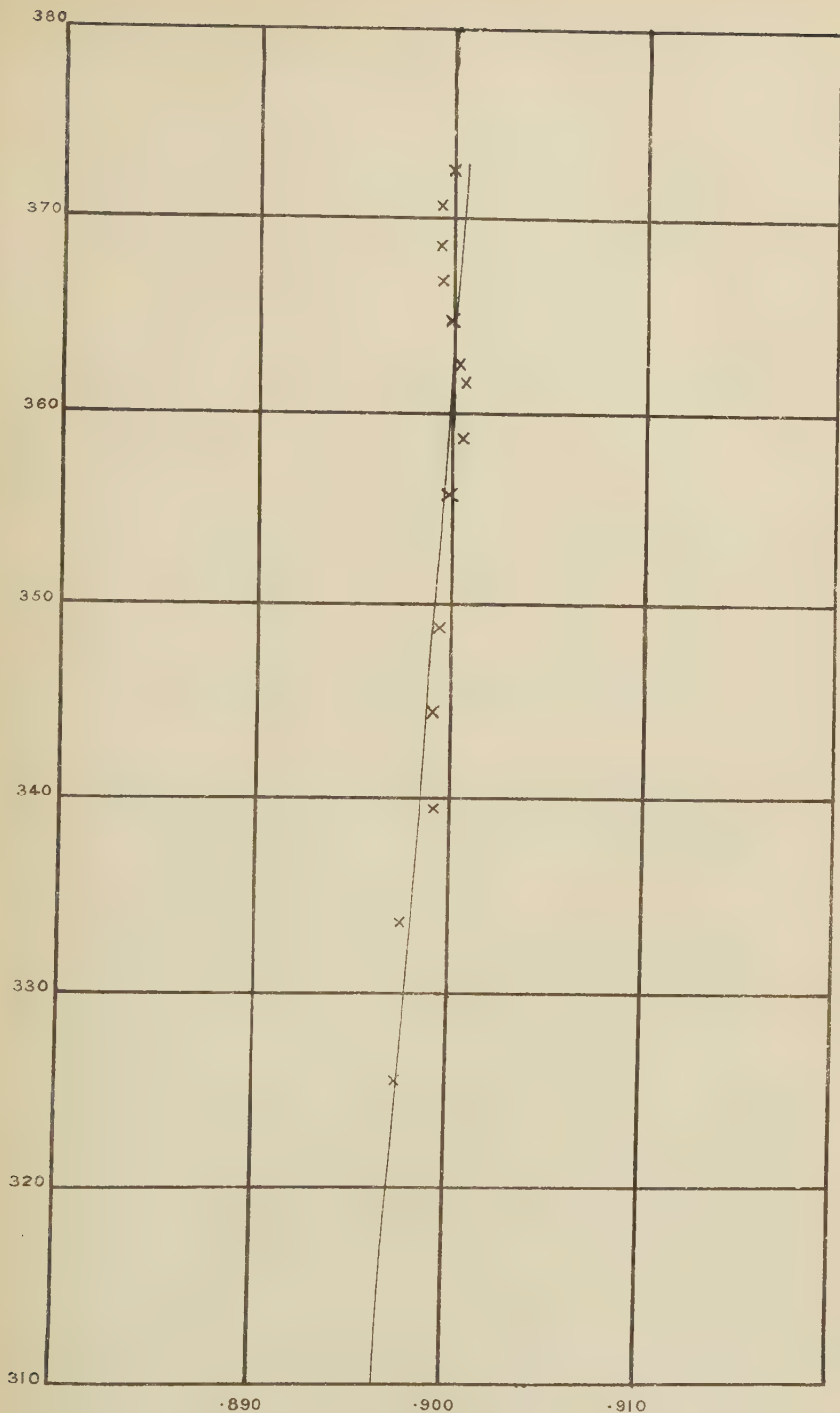
In the following diagram the *absolute temperatures* of water at vapour pressures between 50 and 700 mm. are taken as ordinates, and the *ratios of water to methyl alcohol* at pressures between 50 and 700 mm. as *abscissæ*. It will be seen that the points representing the relation of the ratio of the absolute temperatures of the two bodies to the absolute temperature of one of them (in this case water) fall in a straight line. As might be expected, some of the points (representing the relation of the ratio of the absolute temperature to the temperature of water) fall slightly to one or other side of the straight line drawn to pass through them. Such deviations are due to experimental errors, and can be corrected by taking points on the line itself corresponding to the same absolute temperature of water: these are the corrected ratios.

In the case of the alcohols and acids, I calculated the ratio of the absolute temperature of each of them to water at the same vapour pressure, water being taken as the standard substance, since the determination of the vapour pressures for that substance between 0° and 100° (*i.e.* up to 1 atmosphere) are more reliable than those of any other substance.

These ratios referred to water are given on Table VIII. (water being taken as 1).

I next found the relation of the ratio of the alcohols and acids to the absolute temperature of water, and the value of *r* at different vapour pressures, graphically. Here, as in the case already described, the points representing the relation of the ratio of the alcohol or acid and water

TEMPERATURES OF WATER AT KNOWN VAPOUR PRESSURES.



RATIO OF ABSOLUTE TEMPERATURE OF METHYL ALCOHOL TO WATER

to the absolute temperature of water fall nearly in a straight line; and where a divergence occurs, points on the line itself are taken as corrected ratios corresponding to the absolute temperature of water.

Now, having obtained the smoothed or corrected ratios, I was able to calculate the absolute temperature of the alcohols and acids, by multiplying those of water by the smoothed or corrected ratios.

Finally, as the vapour pressure corresponding to the absolute temperature of water was known, the corrected absolute temperature at a similar vapour pressure is obtained.

These absolute temperatures were then reduced to degrees centigrade, and were compared with the observed results (as shown on Table IX.)

It will be seen that the two sets of numbers agree pretty closely, with one or two exceptions; obviously we have a simple method for smoothing the observed results of vapour pressure determinations.

Lastly, it follows from this, that if we know accurately the vapour pressure of one substance (say water), we only require two, or better three, accurate determinations of the vapour pressure of any other substance, at temperatures moderately far apart, in order to be able to calculate the vapour pressure of this substance at any required temperature, or rather to calculate the temperature corresponding to any other pressure within the limits of pressures comprised in the standard substance.

VAPOUR PRESSURES.—TABLE I.

METHYL ALCOHOL.					ETHYL ALCOHOL.			
No.	1st Experiment.		2nd Experiment.		1st Experiment.		2nd Experiment.	
	Temp. in °C.	Pres. in Mm.	Temp. in °C.	Pres. in Mm.	Temp. in °C.	Pres. in Mm.	Temp. in °C.	Pres. in Mm.
1	−8.3	17.3	−10.1	15.05	.....	.....	.....	.....
2	−7.3	19.2	−7.3	18.32	4.2	16.89	−3.3	10.23
3	−5.3	21.24	−6.3	19.09	4.8	17.94	+7.3	21.39
4	−3.3	24.33	−6.3	19.44	8.8	23.31	13.6	30.67
5	−2.3	25.23	−4.8	20.54	9.8	24.51	19.8	45.22
6	+0.7	32.06	−1.7	26.92	10.7	25.80	23.5	56.25
7	2.2	35.15	+0.2	28.67	17.2	38.57	26.8	68.96
8	4.2	38.30	4.7	36.89	21.8	50.72	29.6	80.61
9	6.25	43.88	7.7	48.87	22.6	51.96	30.7	83.86
10	8.5	48.97	12.2	58.48	23.1	54.86	32.8	95.10
11	11.2	55.82	14.7	68.72	25.3	62.48	34.8	104.81
12	12.0	59.84	20.7	94.03	27.3	71.11	37.3	119.97
13	16.7	77.99	23.7	112.19	30.7	81.86	42.2	155.59
14	22.7	108.96	25.7	124.85	35.3	107.22	43.8	165.41
15	27.3	133.55	31.7	158.07	36.6	114.59	46.5	189.56
16	30.2	155.34	36.2	202.83	40.1	138.41	50.05	226.99
17	33.3	183.77	46.6	332.37	43.1	162.96	52.8	257.52
18	39.2	235.13	54.7	459.22	47.2	199.18	55.50	258.49
19	43.7	289.84	58.7	552.47	49.6	222.87	59.8	349.02
20	49.2	370.26	66.45	754.9	53.7	269.83	65.8	451.48
21	56.7	500.20	.....	.....	57.3	320.87	68.8	513.76
22	59.9	584.24	.....	.....	61.0	370.12	71.1	569.64
23	65.7	753.05	.....	.....	.....	.....	73.8	642.98

VAPOUR PRESSURES.—TABLE II.

[illegible]

VAPOUR PRESSURES.—TABLE III.

ISO-AMYL ALCOHOL.					GLYCERINE.			
No.	1st Experiment.		2nd Experiment.		1st Experiment.		2nd Experiment.	
	Temp. in °C.	Pres. in Mm.	Temp. in °C.	Pres. in Mm.	Temp. in °C.	Pres. in Mm.	Temp. in °C.	Pres. in Mm.
1	34·7	7·27	35·8	6·896	118·45	0·238	122·8	0·597
2	41·9	9·97	46·5	14·000	118·75	0·298	127·91	0·746
3	53·8	21·87	47·8	15·670	120·77	0·348	135·51	1·165
4	66·68	46·58	58·3	29·34	122·92	0·398	136·52	2·340
5	72·80	63·93	65·55	42·853	123·85	0·448	145·555	3·285
6	77·65	82·87	67·8	48·160	127·91	0·4978	152·34	4·659
7	84·4	116·6	70·3	56·56	130·8	1·891	163·36	7·417
8	90·55	150·98	73·0	65·46	134·8	1·941	169·70	12·059
9	91·9	164·93	74·25	69·613	137·025	2·00	175·52	15·683
10	92·3	167·923	76·8	79·06	138·39	2·191	183·40	20·512
11	95·65	193·08	78·05	85·66	139·04	2·338	192·0	30·62
12	96·8	196·07	81·55	100·04	141·04	2·588	199·8	41·81
13	103·8	276·15	82·05	102·548	141·04	2·387	205·8	52·767
14	104·0	279·04	84·9	107·18	143·645	3·046	211·55	68·703
15	107·0	314·718	85·8	113·609	147·06	3·385	217·3	86·725
16	107·70	319·71	88·95	143·00	151·99	4·083	224·3	115·25
17	109·3	345·96	89·55	145·5	161·25	6·527	227·0	130·535
18	111·5	387·0	90·6	155·56	162·45	8·115	229·8	144·87
19	111·8	388·67	93·7	175·87	171·05	12·694	237·1	183·503
20	112·8	399·80	95·65	190·41	172·80	12·745	246·4	239·95
21	115·8	452·2	99·2	220·60	183·25	20·461	248·5	258·627
22	118·8	524·21	101·8	253·59	195·30	34·369	245·3	266·85
23	120·8	536·81	103·7	273·52	200·8	44·865	257·3	347·092
24	123·5	598·4	106·8	304·74	201·3	45·61	.....	.....
25	124·8	628·92	108·8	334·42	211·5	65·610	.....	.....
26	128·55	681·64	110·9	370·44	220·3	100·813	.....	.....
27	.....	.....	114·3	417·7	229·5	137·95	.....	.....
28	.....	.....	121·1	524·36	241·80	201·225	.....	.....
29	.....	.....	123·6	591·75	250·3	231·872	.....	.....
30	.....	.....	.....	.....	260·4	385·326	.....	.....

VAPOUR PRESSURES.—TABLE IV.

ACETIC ACID.					FORMIC ACID.			
No.	1st Experiment.		2nd Experiment.		1st Experiment.		3rd Experiment.	
	Temp. in °C.	Pres. in Mm.	Temp. in °C.	Pres. in Mm.	Temp. in °C.	Pres. in Mm.	Temp. in °C.	Pres. in Mm.
1	2.72	4.0	5.59	4.9	55.9	151.9	5.7	13.46
2	7.06	5.25	6.11	5.0	61.1	185.39	6.1	14.60
3	10.60	6.50	6.87	5.1	68.7	245.2	7.2	13.46
4	15.50	9.10	7.62	5.5	76.2	318.72	10.2	17.44
5	20.10	12.00	8.27	5.9	82.7	391.23	13.2	20.93
6	31.30	21.80	9.7	6.2	87.7	467.47	21.7	32.94
7	36.10	28.30	10.7	6.75	91.2	529.03	29.7	48.33
8	40.1	34.3	14.72	8.5	92.7	562.17	35.7	65.02
9	48.5	51.7	17.0	9.75	96.6	648.89	44.3	84.82
10	57.4	78.7	25.6	15.95	97.9	677.79	46.2	99.165
11	59.6	87.6			100.45	728.43	57.2	152.96
12	68.5	127.5			101.7	762.52		
13	69.1	131.9			2nd Experiment.			
14	73.2	156.2						
15	81.65	215.2			18.5	28.657		
16	91.4	307.9			22.7	34.588		
17	100.6	425.2			29.7	47.844		
18	105.45	501.8			39.1	73.262		
19	110.4	587.1			44.45	82.97		
20	114.1	657.5			57.3	156.89		
21	117.15	717.9			64.9	207.423		
					68.6	238.22		
					71.7	276.9		
					75.2	310.088		

VAPOUR PRESSURES.—TABLE V.

[illegible]

VAPOUR PRESSURES.—TABLE VI.

ISO-VALERIC ACID.						
No.	1st Experiment.		2nd Experiment.		3rd Experiment.	
	Temp. in °C.	Pres. in Mm.	Temp. in °C.	Pres. in Mm.	Temp. in °C.	Pres. in Mm.
1	51·3	2·588	51·79	2·7417	55·4	3·3886
2	59·4	3·635	56·25	3·335	73·51	10·714
3	60·8	4·678	58·74	3·9323	88·85	23·99
4	69·9	8·212	62·725	4·977	96·10	34·882
5	88·2	22·891	65·45	5·725	106·22	58·149
6	92·9	28·468	73·51	9·955	111·36	62·588
7	102·4	46·982	84·12	18·914	115·42	80·727
8	107·8	56·225	89·35	24·291	123·85	122·595
9	111·8	74·354	92·52	28·372	130·0	154·785
10	120·55	104·96	93·32	29·867	133·01	174·01
11	124·4	125·71	93·82	31·087	135·025	185·552
12	128·8	155·873	96·81	35·977	138·04	218·262
13	131·9	186·929	101·38	42·45	142·25	253·443
14	136·4	212·014	106·275	55·891	146·36	292·31
15	142·0	264·05	112·09	63·805	151·29	349·716
16	145·8	299·31	112·62	72·273	155·01	399·95
17	151·8	370·674	114·65	81·482	155·11	398·611
18	155·8	436·72	116·70	88·799	157·2	434·531
19	157·6	479·06	124·05	122·298	158·26	440·91
20	161·3	557·0	133·0	175·159	163·45	526·52
21	173·3	645·19	138·25	218·114	171·15	673·23
22	.....	.....	143·05	256·192	174·93	744·999
23	.....	.....	148·67	312·085	.....	.....
24	.....	.....	150·3	368·386	.....	.....
25	.....	.....	153·1	369·531	.....	.....
26	.....	.....	158·27	434·039	.....	.....
27	.....	.....	162·4	492·774	.....	.....
28	.....	.....	165·625	551·877	.....	.....
29	.....	.....	171·25	673·252	.....	.....
30	.....	.....	176·0	745·587	.....	.....

Comparison of the Ratio of the Absolute Temperatures of Alcohols and Acids for Vapour Pressures between 50 and 750 Mm.

TABLE VII.

ALCOHOLS.										ACIDS.									
Mm.	CH ₃ OH to	C ₂ H ₅ OH	C ₂ H ₅ OH to	Normal C ₃ H ₇ OH	C ₃ H ₇ OH to	Iso C ₄ H ₉ OH	C ₄ H ₉ OH to	Iso C ₅ H ₁₁ OH	HCOOH to	CH ₃ COOH	CH ₃ COOH to	C ₂ H ₅ COOH	C ₂ H ₅ COOH to	Iso C ₃ H ₇ COOH	Iso C ₃ H ₇ COOH to	Iso C ₄ H ₉ COOH	Iso C ₄ H ₉ COOH to		
50	I	1'045	I	1'062	I	1'027	I	1'059	I	1'059	I	1'071	I	1'037	I	1'053			
100		1'042	.....	1'060	.....	1'028	.....	1'058	.....	1'049	.....	1'072	.....	1'035	.....	1'054			
150		1'042	.....	1'060	.....	1'027	.....	1'059	.....	1'049	.....	1'069	.....	1'031	.....	1'056			
200		1'037	.....	1'059	.....	1'026	.....	1'060	.....	1'048	.....	1'069	.....	1'030	.....	1'056			
250		1'037	.....	1'059	.....	1'026	.....	1'059	.....	1'048	.....	1'067	.....	1'031	.....	1'053			
300		1'036	.....	1'059	.....	1'027	.....	1'059	.....	1'048	.....	1'062	.....	1'033	.....	1'053			
350		1'036	.....	1'058	.....	1'028	.....	1'057	.....	1'047	.....	1'061	.....	1'033	.....	1'052			
400		1'035	.....	1'058	.....	1'028	.....	1'059	.....	1'046	.....	1'068	.....	1'033	.....	1'054			
450		1'035	.....	1'056	.....	1'028	.....	1'059	.....	1'044	.....	1'061	.....	1'032	.....	1'051			
500		1'036	.....	1'056	.....	1'028	.....	1'059	.....	1'044	.....	1'060	.....	1'031	.....	1'051			
550		1'036	.....	1'054	.....	1'028	.....	1'059	.....	1'044	.....	1'059	.....	1'031	.....	1'051			
600		1'036	.....	1'054	.....	1'029	.....	1'059	.....	1'046	.....	1'059	.....	1'031	.....	1'051			
650		1'035	.....	1'053	.....	1'029	.....	1'059	.....	1'047	.....	1'057	.....	1'032	.....	1'051			
700		1'035	.....	1'053	.....	1'029	.....	1'059	.....	1'048	.....	1'056	.....	1'032	.....	1'052			
750		1'036	.....	1'051	.....	1'029	.....	1'059	.....	1'049	.....	1'054	.....	1'031	.....	1'053			

TABLE VIII.

Mm. Press.	Water H ₂ O	ALCOHOLS.						ACIDS.				
		Methyl Alcohol. CH ₄ O	Ethyl Alcohol. C ₂ H ₆ O	Normal Propyl Alcohol. C ₃ H ₈ O	Iso-Butyl Alcohol. C ₄ H ₁₀ O	Iso-Amyl Alcohol. C ₅ H ₁₂ O	Glycerine. C ₃ H ₈ O ₃	Formic Acid. CH ₂ O ₂	Acetic Acid. C ₂ H ₄ O ₂	Propionic Acid. C ₃ H ₆ O ₂	Iso- Butyric Acid. C ₄ H ₈ O ₂	Iso- Valeric Acid. C ₅ H ₁₀ O ₂
50	I	0'9059	0'9470	1'0064	1'0344	1'0964	1'213	0'9766	1'0344	1'1083	1'1494	1'2111
100		0'9079	0'9455	1'0021	1'0311	1'0918	1'214	0'9852	1'0333	1'1078	1'1463	1'2082
150		0'9066	0'9451	1'0018	1'0292	1'0911	1'216	0'9880	1'0366	1'1090	1'1432	1'2083
200		0'9096	0'9435	0'9997	1'0262	1'0890	1'214	0'9897	1'0380	1'1087	1'1411	1'2054
250		0'9109	0'9439	1'0000	1'0264	1'0874	1'222	0'9930	1'0410	1'1089	1'1434	1'2050
300		0'9097	0'9429	0'9983	1'0261	1'0860	1'221	0'9945	1'0434	1'1072	1'1433	1'2049
350		0'9101	0'9430	0'9977	1'0261	1'0849	1'222	0'9977	1'0440	1'1081	1'1441	1'2030
400		0'9101	0'9424	0'9966	1'0247	1'0830	.....	0'9994	1'0447	1'1082	1'1446	1'2039
450		0'9111	0'9431	0'9953	1'0237	1'0837	.....	1'0017	1'0457	1'1098	1'1452	1'2039
500		0'9110	0'9434	0'9958	1'0225	1'0824	.....	1'0022	1'0462	1'1098	1'1447	1'2037
550		0'9102	0'9427	0'9926	1'0225	1'0818	.....	1'0015	1'0470	1'1096	1'1444	1'2037
600		0'9099	0'9414	0'9911	1'0215	1'0810	.....	1'0027	1'0483	1'1089	1'1435	1'2032
650		0'9097	0'9418	0'9911	1'0206	1'0805	.....	1'0027	1'0491	1'1082	1'1438	1'2026
700		0'9093	0'9418	0'9903	1'0205	1'0809	.....	1'0033	1'0507	1'1079	1'1433	1'2032
750		0'9100	0'9425	0'9909	1'0204	1'0810	.....	1'0043	1'0526	1'1091	1'1439	1'2050

Observed and Corrected Vapour Pressures Compared.—TABLE IX.

Pres. in Mm.	METHYL ALCOHOL.		ETHYL ALCOHOL.		NORMAL PROPYL ALCOHOL.		ISO- BUTYL ALCOHOL.		ISO- AMYL ALCOHOL.	
	Observed.	Calculated.	Observed.	Calculated.	Observed.	Calculated.	Observed.	Calculated.	Observed.	Calculated.
50	9.0	9.34	21.8	21.76	40.3	40.29	49.0	49.04	68.3	67.93
100	21.8	21.76	34.0	34.17	52.4	52.67	61.8	61.76	81.5	81.57
150	29.0	29.58	41.8	41.81	60.7	60.50	69.8	69.79	90.2	90.07
200	35.9	35.60	47.4	47.83	66.5	66.5	75.5	76.07	96.8	96.64
250	40.5	40.8	52.1	52.14	71.4	70.88	80.5	80.65	101.5	101.46
300	44.4	44.29	56.0	56.36	75.3	75.06	85.0	84.85	105.9	105.98
350	47.9	47.70	59.5	59.71	78.8	78.44	88.8	88.38	109.5	109.68
400	51.0	50.93	62.5	62.81	81.8	81.51	91.8	91.55	112.8	112.8
450	54.0	53.90	65.5	65.47	84.2	84.14	94.4	94.26	115.9	116.0
500	56.5	56.17	68.3	68.04	86.9	86.70	97.0	96.90	118.5	118.71
550	58.5	58.50	70.5	70.33	89.0	88.97	99.4	99.17	121.0	121.16
600	60.5	60.66	72.5	72.35	90.8	91.00	101.4	101.36	123.2	123.54
650	62.4	62.42	74.1	74.43	92.5	93.00	103.3	103.44	125.4	125.60
700	64.1	64.63	76.1	76.23	94.1	94.77	105.3	105.3	127.7	127.61
750	65.9	66.21	78.0	77.8	96.0	96.45	107.0	106.96	129.6	129.30

Observed and Corrected Vapour Pressures Compared.—TABLE IX. (continued).

Pres. in Mm.	FORMIC ACID.		ACETIC ACID.		PROPIONIC ACID.		BUTYRIC ACID.		ISO- VALERIC ACID.	
	Observed.	Calculated.	Observed.	Calculated.	Observed.	Calculated.	Observed.	Calculated.	Observed.	Calculated.
50	31	31.44	48.1	46.70	72.0	72.0	84.8	83.43	104.0	104.91
100	46.9	46.40	62.5	62.20	86.7	86.86	99.2	98.71	119.3	119.53
150	56.1	56.10	72.3	71.90	96.4	96.4	107.8	108.30	129.5	129.28
200	63.1	63.37	79.5	79.53	103.5	103.44	114.5	115.6	136.5	136.89
250	69.0	68.92	85.5	85.17	108.9	108.76	120.8	121.10	142.0	142.41
300	74.1	73.98	90.7	90.45	113.3	113.79	125.9	126.21	147.4	147.66
350	78.8	78.33	95.1	94.83	117.7	117.89	130.4	130.43	151.5	151.92
400	82.8	82.30	98.9	98.91	121.5	121.70	134.5	134.49	155.5	155.87
450	86.5	85.61	102.2	102.40	125.3	124.95	138.0	137.58	159.0	159.18
500	89.5	88.75	105.4	105.70	128.4	128.06	141.0	140.77	162.2	162.28
550	92.0	91.77	108.3	108.68	131.1	130.85	143.8	143.63	165.0	165.30
600	94.5	94.41	111.2	111.38	133.4	133.39	146.1	146.27	167.8	167.8
650	96.7	96.97	113.8	113.95	135.6	135.83	148.7	148.77	170.4	170.54
700	98.9	99.41	116.5	116.50	137.7	138.07	150.8	151.08	173.0	172.95
750	101.0	101.45	119.0	119.43	140.0	139.96	153.0	153.0	175.8	174.78

